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$$a = \frac{bm}{\sqrt{b^2 - n^2}}.$$

The area of the ellipse, which is easily found by integration, is  $\pi ab$ . Substituting the above value of  $a$  in this expression we have

$$\frac{\pi b^2 m}{\sqrt{b^2 - n^2}},$$

which is a function,  $f(b)$ , of the independent variable  $b$ . To find the minimum value of  $f(b)$  find the values of  $b$  which cause the first derivative to vanish.

$$f'(b) = \pi m \frac{2b(b^2 - n^2) - b^3}{(b^2 - n^2)^{3/2}} = 0.$$

Solving this equation we find  $b$  to be 0 or  $n\sqrt{2}$ . The latter value is obviously the desired one. The corresponding value of  $a$  is  $m\sqrt{2}$ .

Hence, the area is  $\pi m\sqrt{2} \cdot n\sqrt{2}$  or  $2\pi mn$ .

From geometrical considerations it does not seem necessary to show that  $f''(b)$  is positive and that, therefore,  $f(b)$  is a true minimum.

Also solved similarly by H. S. UHLER, H. C. FEEMSTER, GEORGE W. HARTWELL, and H. L. AGARD.

*Note.*—The above solution assumes that the bricks are laid side by side without mortar, whereas in a “brick wall” they are laid so as to *break joints*. Very possibly the question as answered is the one really intended by the proposer but the ellipse found certainly does not inclose four bricks as they are laid in a *brick wall*. EDITORS.

#### 394. Proposed by W. W. BURTON, Macon, Ga.

A horse runs 10 miles per hour on a circular race-track in the center of which is an arc-light. How fast will his shadow move along a straight board fence (tangent to the track at the starting point) when he has completed one eighth of the circuit?

SOLUTION BY C. E. HORNE, Westminster College, Colorado.

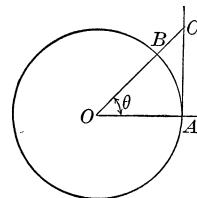
Let  $B$  and  $C$  be the position of the horse and shadow at any time after starting from the point of tangency,  $A$ . Let  $AB = s$ ,  $AC = y$ , angle  $AOC = \theta$ , and  $r$  = the radius of the ring. Then  $s = r\theta$  (1) and  $y = r \tan \theta$  (2). From (1),  $ds/dt = r(d\theta/dt)$ , the rate of the horse and from (2),  $dy/dt = r \sec^2 \theta (d\theta/dt)$ , the rate of the shadow,  $= \sec^2 \theta (ds/dt) = 10 \sec^2 \theta = 20$  miles per hour when  $\theta = \pi/4$ .

Also solved by A. H. HOLMES, H. L. AGARD, J. A. CAPARO, D. RUMBLE, W. C. EELLS, CLIFFORD N. MILLS, HORACE OLSON, H. L. AGARD, and GEORGE W. HARTWELL.

#### 395. Proposed by W. W. BURTON, Mercer University, Macon, Ga.

Into a full conical wine glass whose depth is  $a$  and whose angle at the base is  $2\alpha$  there is carefully dropped a spherical ball of such size as to cause the greatest overflow. Show that the radius of the ball is  $a \sin \alpha / (\sin \alpha + \cos 2\alpha)$ .

From Woods and Bailey's *A Course in Mathematics* (1907), Volume I, page 213.



SOLUTION BY H. S. UHLER, Yale University.

Let the sphere touch the inside of the cone near the rim with its center above the plane of the edge. Also, let  $h$  and  $r$  denote, respectively, the altitude of the submerged spherical segment and the radius of the sphere. Then  $h = a + r(1 - \csc \alpha)$ . The volume  $v$  of the liquid spilled is, of course, equal to the volume of the submerged spherical segment.

The volume of a spherical segment of altitude  $h$ , and radius of base  $r_1$  is  $\frac{1}{6}\pi h^3 + \frac{1}{2}\pi h r_1^2$ . Here,

$$r_1 = \sqrt{2rh - h^2}, \quad \text{hence} \quad v = \pi h^2(r - \frac{1}{3}h).$$